UNITED STATES MARINE CORPS

LESSON PLAN

AIR MASS MODIFICATION

INTRODUCTION:

1. Gain Attention. We should all be familiar with what a cold front is and understand that when we hear a cold front is approaching our area, we expect bad weather, right? But after the cold front passes, why does good weather return? Why do we experience colder temperatures in the middle of summer?

2. Overview. During this period of instruction, the student(s) shall be introduced to the different processes that aid to the modification of an air mass once it leaves its source region.

3. Introduce Learning Objectives.

a. Terminal Learning Objective. Without the aid of references, but in accordance with the instruction, the student(s) explain how air masses undergo thermal and dynamic modification.

b. Enabling Learning Objective(s). Without the aid of references, but in accordance with the instruction, the student(s) shall:

(1) State the thermal classification for colder and warmer air masses and explain how these classifications relate to stability.

(2) Provide an example of the characteristics an air mass receives when it is undergoing thermal modification.

(3) State the process of dynamic modification and explain how it affects the properties of an air mass.

4. Method/Media. This period of instruction will be taught using the lecture method with the aid of a Macromedia Flash presentation "QMMPH1-Introduction to the Earth's Dynamics".

5. Evaluation. The student shall not be evaluated at the conclusion of the period of instruction.

TRANSITION. When an air mass forms in its source region, it has acquired certain characteristics that it maintains. But how do we experience changes in our weather? The next section focuses on how and why air masses begin to move.

BODY:

1. Air Mass Movement & Modification. When an air mass leaves its source region, it properties and characteristics begin to change. Part of the change comes from thermal modifications (heating or cooling from below); part of the change comes from dynamic modifications (uplift,

convergence, subsidence, and turbulence), and occasionally due to the addition or subtraction of moisture.

a. Once the air mass moves from its source region, it not only begins to modify the weather over the are through which it is transversing, but the air mass is also being gradually modified by the surface over which it moving. Warming or cooling from below, the loss or addition of moisture, and vertical movements in the air, all impact the moving air mass.

b. When continental Arctic or Polar air moves over the ocean in the winter, it will undergo a sizeable change. The dry continental air receives a mass quantity of evaporation from the water surface it is mow moving over. Because the water is warmer than the air directly above it, the air is heated from below. There is now a cold layer overtopping a warm layer which leads to instability and upward vertical movements that transport the warmer air and moisture to higher levels in the atmosphere. In a matter of days, the once very cold and dry air mass is now transformed into an unstable cool and moist air mass, maritime Polar.

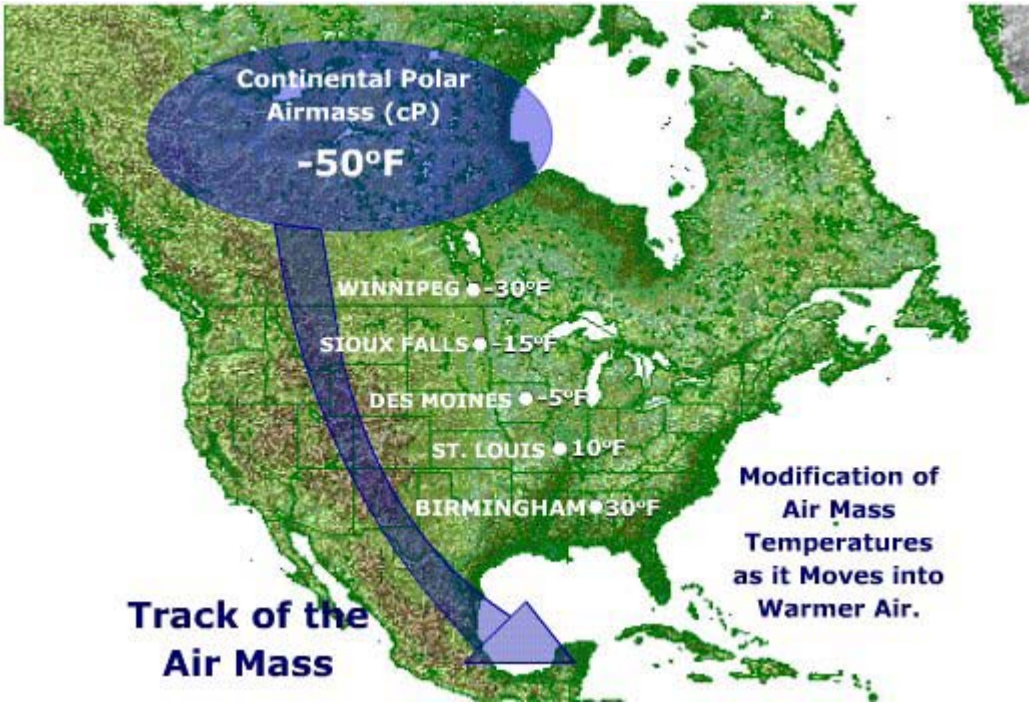

Figure 1 – An example of how a continental polar air mass modifies as it moves southward over relatively warmer air.

2. Classifying Thermal Movement and Modification.

a. Colder Moving Over Warmer Surface. When the air mass is colder than the surface that it is moving over (like the example above), a lowercase "*k*" is added to its classification (cPk).

(1) A colder air mass that moves over a warmer surface will be warmed from below, in its lowest layers. The warmer air at

the surface then wants to rise vertically which produces greater instability and enhances cloud formation and precipitation.

(2) Cold air above warmer air creates a steeper lapse rate, low-level instability, increased convection and turbulent mixing at the surface. If precipitation occurs, it will be in the form of showers or thunderstorms. Visibility is normally good (except in precipitation) because of the mixing of the air.

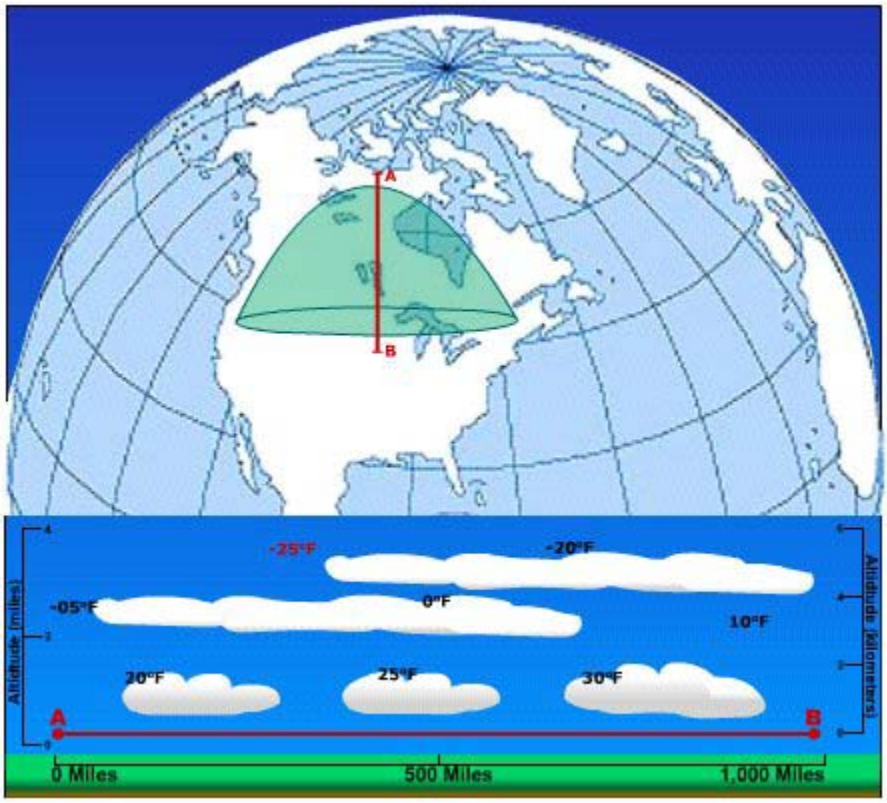

Figure 2 – As the air mass moves from point A to point B, it is moving over a relatively warmer surface, warming the cooler air mass from below.

b. Warmer Moving Over a Colder Surface. When an air mass moves out of its source region, and the air is warmer than the surface of the region that is occupies it, a lowercase "*w*" is added to its classification (cPw).

(1) When the air mass is warmer than the surface over which it is moving, then the lowest layers of the air mass will be cooled from below. A surface inversion (increasing temperatures with height) will develop and stable conditions will result.

(2) Stable conditions suppress upward vertical movements. Should clouds form in this stable environment, they will be stratified and precipitation will be light to moderate in intensity. Warm air above cooler air creates a stable lapse

rate, accumulation of dust, smoke and pollutants that restrict visibility are often trapped below the inversion. Advection fog is also quite common.

3. Dynamic Movement and Modification. Dynamic modifications are usually independent of thermal modification and result when upward and downward vertical motions affect the stability of an air mass from topography, cyclones, or anticyclones.

a. Considerable modifications occur when an air mass is drawn into a low-pressure system by its converging surface winds. Convergence and lifting dominate, and now the air mass is unstable.

b. Conversely, subsidence from high-pressure systems acts to stabilize an air mass.

c. Topography can affect the air mass in two different ways. As the air mass approaches the windward side of the mountain, the air is forced to rise, rendering it unstable. As the air mass descends the mountain range, the air begins to subside and renders the air mass more stable.

4. Examples of Air Mass Movement and Modification.

a. A Canadian cP air mass extending northward into the Arctic regions. This would be considered a stable air mass with warm air aloft. Here, the surface layer of air undergoes rapid transformation, but, because of the stability produced by this surface cooling, the effects do not extend to great heights.

b. A Continental Polar Cold air mass is one that is formed over a cold, large body of land but has moved out of its source region to an area that has a surface that is warmer than the air mass. An example of this would be the Canadian cP air mass extending southward over the warmer United States. In such a situation, the surface layer of air undergoes less rapid modification, but the effects extend too much higher levels because of the turbulent and convective exchange of heat and moisture.

c. A Maritime Tropical Cold air mass is one that is formed over a warm, large body of water but has moved out of its source region to an area that has a warmer surface than the air mass. An example of this would be the mT air mass originating over the eastern Pacific Ocean moving east over Mexico. This would be considered a very unstable air mass with warm, moist air above even warmer air below, and high moisture content favorable for turbulent mixing and convection.

d. A Maritime Tropical Warm air mass is one that is formed over a warm, large body of water but has moved out of its source region to an area that has a colder surface than the air mass. An example of this would be the mT air mass originating over the eastern Pacific Ocean moving northeast over Alaska and Canada. This would be a

rather stable air mass with warm, moist air aloft, and surface cooling that does not extend to great heights.

OPPORTUNITY FOR QUESTIONS:

1. Questions from the Class. At this time are there any questions from the student(s) pertaining to the material that has just been presented?

2. Questions to the Class.

a. QUESTION. How would an air mass be modified if it migrated from Northwestern Canada to the central United States region?

b. ANSWER. cP reclassified as cPk.

c. QUESTION. What type of stability would be related to an air mass that originally was mT, but migrated to an area of cooler, drier characteristics? Why?

d. ANSWER. The air mass would be relatively stable due to the warm, moist air aloft, and surface cooling that takes place.

SUMMARY: Although air mass classification is the first step in our understanding air masses, modification is crucial to understanding the weather patterns throughout the atmosphere. An air mass and the contrast, or lack of, in the region that the air mass occupies is what creates the weather in that region. To use caution however, the interaction of an air mass with the earth's surface is not the only system that produces weather effects. Convergence, divergence, and subsidence also are very important in finding lapse rates and stability.

REFERENCE:

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Lutgens, Frederick K. and Tarbuck, Edward J. The Atmosphere, An Introduction to Meteorology. 9th edition. Pearson Education Inc, 2004.

McKnight, Tom L. and Hess, Darrel. Physical Geography, A landscape Appreciation. 7th Edition. Pearson Education, Inc. 2004.